

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (withdrawn): In combination with a load lock apparatus for facilitating transfer of parts between a room at ambient atmospheric pressure and a vacuum processing chamber maintained at a pressure less than one torr, of the type wherein the load lock apparatus has an evacuable load lock chamber, an exterior door positioned between the load lock chamber and the room, a interior door positioned between the load lock chamber and the processing chamber, a exterior door actuator that is responsive to an exterior door control signal to open or close the exterior door, an interior door actuator that is responsive to an interior door control signal to open or close the interior door, and a vacuum pump connected to the load lock chamber for evacuating the load lock chamber, the improvement which comprises:

a combination differential and absolute pressure transducer with (i) a manifold connected in fluid flow relation to the load lock chamber so that pressure in the manifold is equal to pressure in the load lock chamber, (ii) a differential pressure sensor that is capable of sensing a pressure difference between a first side of the differential pressure sensor and a second side of the differential pressure sensor, said differential pressure sensor being connected to the manifold and mounted such that said first side is exposed to the ambient atmospheric pressure in the room and such that the second side is exposed to the pressure in the manifold, (iii) a differential pressure transducer circuit connected to the differential pressure sensor and which is capable of generating an exterior door control signal at a preset differential pressure value, (iv) an absolute pressure sensor connected to the manifold in such a manner that the absolute pressure sensor is exposed to the pressure in the manifold, and (v) an absolute pressure transducer circuit connected to the absolute pressure sensor and which is capable of generating an interior door control signal at a preset absolute pressure value;

an exterior door control link connected between the differential pressure transducer circuit and the exterior door actuator, said exterior door control link being

capable of delivering exterior door control signals generated by the differential pressure transducer circuit to the exterior door actuator; and

an interior door control link connected between the absolute pressure transducer circuit and the interior door actuator, said interior door control link being capable of delivering interior door control signals generated by the absolute pressure transducer circuit to the interior door actuator.

Claim 2 (withdrawn) The improvement of claim 1, wherein the absolute pressure sensor of the combination differential and absolute pressure transducer comprises a pirani sensor with a resistivity that varies as a function of the pressure in the manifold, and wherein the absolute pressure transducer circuit includes a pirani bridge circuit that incorporates the pirani sensor as a resistive element in the bridge circuit, an analog process circuit connected to the pirani bridge circuit to adjust voltage across the pirani sensor as the pressure in the manifold varies and thereby keep the bridge circuit in balance, and a relay control circuit that monitors voltage across the pirani sensor and generates the interior door control signal when the voltage across the pirani sensor is at a value that corresponds with said preset absolute pressure value.

Claim 3 (withdrawn) The improvement of claim 1, wherein the differential pressure sensor of the combination differential and absolute pressure transducer comprises a capacitance manometer pressure sensor in which a capacitance varies as a function of the differential pressure across a diaphragm that is positioned with the manifold pressure on one side of the diaphragm and ambient atmospheric pressure of the room on another side of the diaphragm, and wherein the differential pressure transducer circuit includes a sensor control circuit that is capable of converting the capacitance to a voltage that corresponds in value to the differential pressure across the diaphragm, and a relay control circuit that monitors the voltage from the sensor control circuit and generates the exterior door control signal when

the voltage of the sensor control circuit corresponds with said preset differential pressure value.

Claims 4 – 7 (cancelled).

Claim 8 (currently amended): A method of automatically controlling a load lock that facilitates transfer of parts between a room at ambient atmospheric pressure and a vacuum transfer or processing chamber maintained at a pressure less than one torr and that has an evacuable load lock chamber, an exterior door positioned between the load lock chamber and the room, a interior door positioned between the load lock chamber and the processing chamber, a exterior door actuator that is responsive to an exterior door control signal to open or close the exterior door, an interior door actuator that is responsive to an interior door control signal to open or close the interior door, and a vacuum pump connected to the load lock chamber for evacuating the load lock chamber, comprising:

~~sensing a differential pressure between the ambient pressure in the room and a pressure in a manifold connected in fluid flow relation to the load lock chamber;~~
~~transducing the sensed differential pressure to a voltage that corresponds in value to the sensed differential pressure;~~
~~producing a differential pressure reference voltage that corresponds in value to the voltage that is transduced from the differential pressure when the differential pressure is at a desired differential pressure value for opening the exterior door;~~
~~comparing the differential pressure reference voltage to the transduced voltage that corresponds in value to the voltage that is transduced from the differential pressure, and, when the transduced voltage equals the differential pressure reference~~

~~voltage, producing the exterior door control signal and delivering the exterior door control signal to the exterior door actuator;~~

~~—— sensing an absolute pressure in the manifold;~~

~~—— transducing the sensed absolute pressure to a voltage that corresponds in value to the absolute pressure;~~

~~—— producing an absolute pressure reference voltage that corresponds in value to the voltage that is transduced from the absolute pressure when the absolute pressure is at a desired absolute pressure for opening the interior door; and~~

~~—— comparing the absolute pressure reference voltage to the transduced voltage that corresponds in value to the absolute pressure, and, when the transduced voltage equals the absolute pressure reference voltage, producing the interior door control signal and delivering the interior door control signal to the interior door actuator~~

connecting a pirani pressure sensor that is capable of measuring absolute pressure at least in a range of 100 torr to 10^{-4} torr and a differential pressure sensor in fluid flow relation to a manifold and mounting the pirani pressure sensor, the differential pressure sensor, and a control circuit in a housing to provide a modular pressure transducer that senses and transduces absolute pressure in the manifold to a voltage that is indicative of the absolute pressure in the manifold and that senses and transduces differential pressure between the manifold and the ambient atmosphere to a voltage that is indicative of the differential pressure between the manifold and the ambient atmosphere, and that also outputs the interior door control signal when the voltage that is indicative of the absolute pressure equals an interior door control reference voltage and outputs the exterior door control signal when the voltage that is

indicative of the differential pressure equals an exterior door control reference voltage;

setting the interior door control reference voltage of the pressure transducer to a level that equals the voltage that is indicative of the absolute pressure in the load lock chamber when the load lock chamber is evacuated to a pressure at which opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock chamber into the transfer or processing chamber;

setting the exterior door control reference voltage of the pressure transducer to a level that equals the voltage that is indicative of the differential pressure between the load lock chamber and the ambient atmosphere at which opening of the exterior door does not cause undesirable rush of air or gas molecules either into or out of the load lock chamber;

connecting the manifold of the pressure transducer in fluid flow relation to the load lock chamber so that the pressure in the manifold is the same as the pressure in the load lock chamber;

connecting an interior door control link between the pressure transducer and the interior door actuator and connecting an exterior door control link between the pressure transducer and the exterior door actuator; and

powering the pressure transducer to produce the interior door control signal and the exterior door control signal in sequence as the load lock chamber is evacuated and then re-filled with gas such that the pressure transducer: (i) provides the interior door control signal to the interior door actuator via the interior door control link to

open the interior door when the load lock chamber has been evacuated to a pressure that is low enough so that such opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock into the transfer or processing chamber; and (ii) provides the exterior door control signal to the exterior door actuator via the exterior door control link to open the exterior door when the load lock chamber has been re-filled with gas to return the pressure in the load lock chamber to a pressure at which opening of the exterior door does not cause undesirable rush of air or gas molecules either into or out of the load lock chamber.

Claim 9 (currently amended): A method of automatically controlling a load lock that facilitates transfer of parts between a room at ambient atmospheric pressure and a vacuum transfer or processing chamber maintained at a pressure less than one torr and that has an evacuable load lock chamber, an exterior door positioned between the load lock chamber and the room, a interior door positioned between the load lock chamber and the transfer or processing chamber, a exterior door actuator that is responsive to an exterior door control signal to open or close the exterior door, an interior door actuator that is responsive to an interior door control signal to open or close the interior door, ~~and~~ a vacuum pump connected to the load lock chamber for evacuating the load lock chamber, and a throttle valve, which slows down effective vacuum pumping speed to reduce turbulence that stirs up particles and contaminants until the pressure in the load lock is pumped down to an intermediate pressure where enough of the air or gases in the load lock are removed so that turbulence does not stir

up such particles and contaminants and which is responsive to a throttle valve signal to then step up the vacuum pumping speed, comprising:

connecting a pressure transducer to the load lock chamber, wherein the pressure transducer includes a pirani sensor that is capable of sensing both absolute pressure in the load lock chamber at least in a range of 100 torr to 10^{-4} torr and a differential pressure sensor that is capable of sensing a differential pressure between the load lock chamber and ambient atmospheric pressure and that is capable of outputting: (i) the throttle valve signal at a settable intermediate absolute pressure set point; (ii) the interior door control signal at a settable low absolute pressure set point; and (iii) the exterior door control signal at a settable differential pressure setpoint;

predetermining setting a desired differential-intermediate absolute pressure value at which to open the exterior door throttle valve to step up the vacuum pumping speed after the pressure in the load lock chamber is pumped down enough so that turbulence does not stir up the particles and contaminants, and predetermining setting a desired low absolute pressure value at which to open the interior door can be opened to allow transfer of parts between the load lock and the transfer or processing chamber without undesirable rush of gas molecules and particulate impurities and water vapor into the transfer or processing chamber, and setting a desired differential pressure value at which to open the exterior door without undesirable flow of air or gas either into or out of the load lock chamber;

sensing actual differential pressure between the load lock chamber and the ambient pressure in the room and a pressure in a manifold connected in fluid flow relation to the load lock chamber;

~~comparing the actual differential pressure to the predetermined differential pressure value, and, when the actual differential pressure equals the predetermined differential pressure value, producing the exterior door control signal and delivering the exterior door control signal to the exterior door actuator;~~

sensing actual absolute pressure in the load lock chamber ~~with a pirani sensor that has an accurate absolute pressure measuring the pressure transducer at least in the range from 100 torr down to 10^{-4} torr or lower~~ the desired low absolute pressure value; and

using the pressure transducer to compare the actual absolute pressure in the load lock chamber to the desired intermediate absolute pressure value set in the pressure transducer at which the throttle valve can be opened to step up the vacuum pumping speed after the pressure in the load lock chamber is pumped down enough so that turbulence does not stir up the particles and contaminants, and, when the actual absolute pressure in the load lock chamber equals the desired intermediate absolute pressure value, producing the throttle valve signal with the pressure transducer to step up the vacuum pumping speed;

~~comparing~~ using the pressure transducer to compare the actual absolute pressure in the load lock chamber to the predetermined desired low absolute pressure value set in the pressure transducer at which the interior door can be opened without undesirable rush of gas molecules and particulate impurities and water vapor into the transfer of processing chamber, and, when the actual absolute pressure in the load lock chamber equals the predetermined desired low absolute pressure value,

producing the interior door control signal with the pressure transducer and delivering the interior door control signal to the interior door actuator;

sensing the actual differential pressure between the ambient pressure in the room and the pressure in the load lock chamber with the pressure transducer; and

using the pressure transducer to compare the actual differential pressure to the predetermined differential pressure value, and, when the actual differential pressure equals the predetermined differential pressure value, producing the exterior door control signal with the pressure transducer and delivering the exterior door control signal to the exterior door actuator.

Claim 10 (new): The method of claim 9, wherein the transfer or processing chamber is maintained at less than 10^{-3} torr and the desired low absolute pressure value at which the interior door can be opened without undesirable rush of gas molecules and particulate impurities and water vapor into the transfer or processing chamber is less than 10^{-3} torr, and including sensing the actual absolute pressure in the load lock chamber with the pressure transducer at levels at least from 100 torr to less than 10^{-3} torr.

Claim 11 (new): A method of providing control signals to a load lock that has an interior door between the load lock and a transfer or processing chamber and an interior door actuator that responds to interior door control signals to open the interior door, a vacuum pump for evacuating the load lock, a throttle valve that slows the vacuum pump-down speed and that responds to a throttle valve control signal to step up the pump-down speed, and an

exterior door for opening and closing the load lock to the ambient atmosphere and that responds to an exterior door control signal to open the exterior door, comprising:

connecting a pirani pressure sensor and a differential pressure sensor in fluid flow relation to a manifold and mounting the regular pirani sensor and the differential pressure sensor together with a control circuit in a housing to provide a modular pressure transducer that senses and transduces absolute pressure in the manifold to a voltage that is indicative of the absolute pressure in the manifold and that senses and transduces differential pressure between the manifold and the ambient atmosphere to a voltage that is indicative of the differential pressure between the manifold and the ambient atmosphere, and that also outputs the throttle valve control signal when the voltage that is indicative of absolute pressure equals a throttle valve control reference voltage, outputs the interior door control signal when the voltage that is indicative of the absolute pressure equals an interior door control reference voltage, and outputs the exterior door control signal when the voltage that is indicative of the differential pressure equals an exterior door control reference voltage;

setting the throttle valve control reference voltage of the pressure transducer to a level that equals the voltage that is indicative of the absolute pressure in the load lock when the load lock is evacuated to a intermediate pressure threshold at which enough of the air or gases in the load lock are removed so that particles and contaminants in the load lock are not stirred up by turbulence at the stepped up pump-down speed;

setting the interior door control reference voltage of the pressure transducer to a level that equals the voltage that is indicative of the absolute pressure in the load lock

when the load lock is evacuated to a pressure at which opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock into the transfer or processing chamber;

setting the exterior door control reference voltage of the pressure transducer to a level that equals the voltage that is indicative of the differential pressure between the load lock and the ambient atmosphere at which opening of the exterior door does not cause undesirable rush of air or gas molecules either into or out of the load lock;

connecting the manifold of the pressure transducer in fluid flow relation to the load lock so that the pressure in the manifold is the same as the pressure in the load lock;

connecting a throttle valve control link between the pressure transducer and the throttle valve;

connecting an interior door control link between the pressure transducer and the interior door actuator;

connecting an exterior door control link between the pressure transducer and the exterior door actuator; and

powering the pressure transducer to produce the throttle valve control signal, the interior door control signal, and the exterior door control signal in sequence as the load lock is evacuated and then re-filled with gas such that the pressure transducer:

(i) provides the throttle valve control signal to the throttle valve via the throttle valve control link to step up the pump-down speed when the load lock has been evacuated to said threshold pressure at which enough of the air or gases in the load lock are removed so that the particles and contaminants in the load lock are not stirred up by

turbulence at the stepped up pump-down speed; (ii) provides the interior door control signal to the interior door actuator via the interior door control link to open the interior door when the load lock has been evacuated to a pressure that is low enough so that such opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock into the transfer or processing chamber; and (iii) provides the exterior door control signal to the exterior door actuator via the exterior door control link to open the exterior door when the load lock has been refilled with gas to return the pressure in the load lock to a pressure at which opening of the exterior door does not cause undesirable rush of air or gas molecules either into or out of the load lock.

Claim 12 (new): The method of claim 11, wherein the pressure that is low enough so that such opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock into the transfer or processing chamber is less than 10^{-3} torr and the pressure transducer produces the interior door control signal when it senses that pressure.

Claim 13 (new): The method of claim 11, wherein the pressure that is low enough so that such opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock into the transfer or processing chamber is in a range between 10^{-3} and 10^{-4} torr, and wherein the pressure transducer senses when the load lock is evacuated to such pressure between 10^{-3} and 10^{-4} torr to produce the interior door control signal at that pressure.

Claim 14 (new): The method of claim 11, wherein the pressure that is low enough so that such opening of the interior door does not cause undesirable rush of gas molecules and particulate impurities and water vapor from the load lock into the transfer or processing chamber is at least as low as 10^{-4} torr, and wherein the pressure transducer senses when the load lock is evacuated to at least as low as 10^{-4} torr to produce the interior door control signal.

Claim 15 (new): The method of claim 11, including routing the throttle valve control signal, the interior door control signal, and the exterior door control signal to the throttle valve control link, to the interior door control link, and to the exterior door control link, respectively, through a common connector on the housing, and connecting the throttle valve control link, the interior door control link, and the exterior door control link to the common connector.

Claim 16 (new): The method of claim 8, including routing the interior door control signal and the exterior door control signal to the interior door control link and to the exterior control link, respectively, through a common connector on the housing, and connecting the interior door control link and the exterior door control link to the common connector.

Claim 17 (new): The method of claim 8, wherein the load lock has a throttle valve that slows the vacuum pump-down speed and that responds to a throttle valve control signal to step up the pump-down speed, and wherein the pressure transducer also outputs the throttle valve

control signal when the voltage that is indicative of absolute pressure in the manifold equals a throttle valve reference voltage, and further including setting the throttle valve control reference voltage of the pressure transducer to a level that equals the voltage that is indicative of the absolute pressure in the load lock chamber when the load lock chamber is evacuated to a intermediate pressure threshold at which enough of the air or gases in the load lock are removed so that particles and contaminants in the load lock are not stirred up by turbulence at the stepped up pump-down speed, and thereby producing the throttle valve control signal with the powered pressure transducer to step up the pump-down speed when the load lock chamber is evacuated to a intermediate pressure threshold at which enough of the air or gases in the load lock are removed so that particles and contaminants in the load lock are not stirred up by turbulence at the stepped up pump-down speed.

Claim 18 (new): The method of claim 8, wherein the pirani sensor is a regular pirani sensor.